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cracks, and edges, and their dislike of open surfaces, is another confusing element to be eliminated, though weaker than heliotropism, and is named contact-irritability, or stereotropism. All these experiments are in general very simple and require almost no apparatus beyond glass cups, tubes, a window that can be partly darkened, and a prism.

Leaf-lice at rest usually turn the oral pole toward the stem, the aboral to the apex of a leaf, or lie in this sense along its veins if at rest. As soon as their wings grow, which may be caused artificially by gradually drying up the leaf, their orientation becomes heliotropic and independent of the leaf and very serviceable for these experiments. At the time of sexual maturity, or at the time of the "wedding flight," many insects become strongly heliotropic, when they are not so before or after. The tendency is to get the axis of the body in the direction of the ray of light, rather than to seek the strongest light. In one case with a rotatory polarization apparatus turning 3-4 times per second with a radius of 30 cm., a fly went round with the ray several times, thrice repeated. This observation of Mach, Loeb thinks, illustrates the constraining power of heliotropism. It might readily be carried further by a centrifugal machine. The protoplasm in the background of the human eye is positively heliotropic; pigment and cones press forward, if illuminated. The heliotropic conception of retinal space-sensations pre-supposes the *continuity* of protoplasm as the irritable substance, and rejects the theory of distinct visual elements—rods and cones. Heliotropic changes determine space-sensations, and this new view simplifies many problems. Heliotropism cannot rest on any specific properties of a central nervous system, for it is common where there are no nerves.

This pamphlet is very interesting, abounds in facts and suggestions and must be read to be fully appreciated. The work was undertaken to show—so we are told at the outset—that in all these phenomena there is no evidence whatever of sensation, instinct, preference, or anything whatever of a psychic nature. All heliotropic, geotropic, stereotropic, or thermotropic motions whatever are in their nature absolutely identical with analogous movements of plants, and he who wishes to see any rudiment or analogue of a bank of intelligent Raphael faces gazing on a central glory, as mediæval artists often dreamed of, in a mass of maggots or larvæ or caterpillars, every one flush with the edge of glass or beaker-rim nearest the light, and staying there for days, should here learn the far higher lesson of law and mechanism, such phenomena properly inculcate. The view of Loeb is in fact as speculative on one side as the anthropomorphism of Verworn (above) is on the other. The violent polemic tone of Loeb and his dogmatism on this old and purely theoretic, and as yet unanswerable question, the entire absence of all morphological or anatomical considerations, especially with the author's mechanical predilections and the *very* meagre evidence suggested to even countenance his revolutionary view of retinal space-perception, are each in different ways to be regretted. His work, however, opens up still wider a new and attractive field, wherein we hope to see psychology gradually strike many strong and deep roots into the rich soil of general biology.

*Der Zeitsinn.* MÜNSTERBERG. Beiträge zur experimentellen Psychologie. H. 2. 1889.

The second number of Münsterberg's series of psychological studies opens with an article in the much-confused field of the "time-sense." After resuming the results of previous experimenters, from Mach to Glass, and presenting at length (three-fifths of the whole paper), the theory to which he has been led by self-observation in the course of experimentation, he finally gives in a brief section the results of an experimental test of his theory. This theory is nothing less than a

complete denial of the existence of a "time-sense;" that is to say, our estimates of time, short intervals as well as long, are not made by an independent sense, but by more or less completely unconscious observation of internal physiological states, especially muscular tensions. Time judgments rest on a kind of psychic synthesis of the sensations that mark the intervals and those that indicate the state of muscular tension, as visual space judgments on the synthesis of visual and muscular sensations. Take a simple example. The subject is given three distinct sounds, the first and second beginning and ending a standard interval with which the subject is to compare that marked off by the second and third. The entrance of the first sound calls up reflexly an adjustment tension in the muscles of the sense organ, which reaches a maximum and declines. At some stage of the decline the second stimulus enters, causing a renewed tension, followed in turn by a decline like the first. Now, if the third stimulus comes at a stage of decline corresponding to that at which the second came, the interval is pronounced the same; if it comes when the decline is less or greater, the interval is judged shorter or longer than the first. For very brief intervals a similar rôle seems to be played by the sensory "memory-after-image," and for longer ones by the widely irradiated tensions and relaxations accompanying respiration. Into the author's extended exposition of the last, and of the complications introduced into it by attention, etc., we shall not enter here. Suffice it to say, that by his theory he explains the very great variety of "intervals of least error" found by different observers (from .4 sec. to 1.25 sec.), the occasional anomalous series reported by some experimenters, and the striking periodicity of the "intervals of least error" observed by others.

The experimental section (only one fifth of the whole, and then not unduly compressed), presents three series of experiments made upon Münsterberg himself; those made on other subjects are only referred to. They were all made with the time-sense apparatus of Wundt, somewhat bettered, and by the method of average error. In the first series the subject was given two sounds marking an interval (6—60 secs.), and required to make a third when the interval after the second sound had become as great as that before it. When the first two sounds were so given that the second always occurred at the same respiratory phase as the first, the average error was 2.9 per cent.; when this was not regarded, it was 10.7 per cent. In the second series three sounds were given, the first and second beginning and ending the standard interval; and the third, at a varying time from the second, beginning the comparison interval, which the subject observed and closed as before. This time the error, when respiration was regarded, was 5.3 per cent; when it was disregarded, 24.0 per cent. In the third series, Münsterberg consciously withdrew attention from the sensations of tension and relaxation, to the complete confusion of his time-judgments, making 4 seconds seem like 12, and 9 like 3.

Münsterberg is certainly right in looking for the explanation of the "time-sense" in the effect on consciousness of physiological processes, and his contribution is an interesting and suggestive one, especially as regards the discordance of previous experimenters. At the same time most of his experiments have to do with considerable intervals, (his explanation of the judgment of short intervals by tension in the sense organs, is left still in the theoretical stage), and are not numerous nor varied enough to exclude other possible influences in addition to that of respiration.

*Schwankungen der Aufmerksamkeit.* MÜNSTERBERG. Ibid.

When one attempts to observe a very faint sensation, the barely audible ticking of a watch or the line of separation between the faintest